

TEXAS MEDICAL CENTER NASA/JOHNSON SPACE CENTER
COOPERATIVE AGREEMENT PROGRAM NCC 9-36, ROUND II

COVER SHEET FOR FINAL REPORT

Name of Subcontractor: Michael E. DeBakey, M.D.
Title: Chancellor Emeritus
Institution: Baylor College of Medicine

1N-52
026043

Name of Project: Development of Telemedicine Capabilities for a Joint U.S.-
Russian Space Biomedical Center for Training and Research

Amount of Grant: ~~5,000,000~~

Amount Spent, if Different from Amount Granted: ~~5,000,000~~

Date Project Was Completed: December 31, 1998

Grants Office: Barbara G. Cochran
Title: Director, Contract and Funding Services
Phone: 713-798-6970
Fax: 713-798-6990

December 31, 1998

NASA/TMC Project Report - Final Report

Development of Telemedicine Capabilities for a Joint U.S.-Russian Space Biomedical Center for Training and Research

This project has encouraged and supported numerous tests and events using telecommunications between the Baylor College of Medicine and principally Moscow State University. (Other sites in Moscow, in the United States and in other parts of the world have participated also.) The tests have focused on telecommunications and protocols for various events. The use of the Internet and public carrier networks to support synchronous and asynchronous communications for educational and consultative events between Houston and Moscow have been examined.

During this project Moscow State University has become an Affiliated Institution of the Baylor College of Medicine. This relationship, which will endure, is due in large part to the acquaintances and shared experiences occasioned by the project.

Three medical education events, nine topics and over two hundred slides have been presented over the Internet for education to audiences at Moscow State University and other sites in the world. A specialist teleconsultation with accompanying educational benefits has been conducted using desktop computers and the Internet. This event involved not only the exchange of echocardiograms, angiograms, electrocardiograms and other patient data but also an audio-video conference between the physicians at the Baylor College of Medicine and the Space Biomedical Center for Training and Research.

Hardware and software at the College from this project will serve Internet-based medical education programs for medical students and faculty in Russia. These assets will be used also to develop new Internet-based features and host additional educational modules for our colleagues in Russia.

Presentations about this project have been delivered at the following conferences.

- Spring Conference of the American Medical Informatics Association in San Jose in May 1997
- Visions for the Future: Distance Learning for the 21st Century at Texas Tech University in Lubbock, TX in March 1997
- Centers for Disease Control and Prevention and the National Immunization Project Conference sponsored by the Texas Department of Health in San Antonio in October 1997.
- A paper, "Hybrid Telemedicine with Personal Computing and the Internet", was presented to the 1998 International Medical Informatics Symposium in Taiwan (MIST '98) in November 1998. The authors are Jed Kenna, Alexander Sukhanov, Jean-Bernard Durand, Michael DeBakey, Oleg Orlov, Yuri Raviachen, and Nancy Wang. The paper was awarded the Best Abstract Award in the Symposium. The presentation originated in Houston and was delivered in Taipei using teleconferencing and the integrated services digital network.

With adequate telecommunications bandwidth and computing power, using software from the public domain, the Internet is a viable approach to deliver medical education. Quoting Dr. DeBakey at the conclusion of the event on October 22, 1996, "These technologies will allow us to improve the standards of health care around the world. The Internet provides an important opportunity for distance learning and the dissemination of medical knowledge in support of this goal."

Michael E. DeBakey, M.D.
Chancellor Emeritus
Baylor College of Medicine

J. E. Kenna
Center for Telemedicine
Baylor College of Medicine

Hybrid Telemedicine with Personal Computing and the Internet

Jed Kenna (jkenna@bcm.tmc.edu)^a, Alexander Sukhanov^b, Jean-Bernard Durand^a,
Michael DeBakey^a, Oleg Orlov^b, Yurii Reviaken^b, Nancy Wang^a

^a *Baylor College of Medicine, Houston, Texas, U.S.A.*

^b *Space Biomedical Center for Training and Research, Moscow, Russia*

Introduction

From the perspective of scheduling, some medical consultations can have asynchronous and synchronous components. Consultations frequently involve the compilation of patient data, its analysis, a consultant's report, and a real-time conference between the referring physician and the consultant. The bandwidth of the Internet with Moscow and advances in the hardware and software of personal computing now make possible telemedicine events with store-and-forward components and real-time components. These are hybrid telemedicine and this paper describes such a case.

Background

The Baylor College of Medicine (BCM) and the Space Biomedical Center for Training and Research (SBC) have developed a working relationship. In the past two years, these institutions have collaborated to present three major medical education events^{1,2,3}, nine topics, and over two hundred slides over the Internet for education to audiences in Moscow. In the spring of 1998, the Chancellor Emeritus of the College was invited to demonstrate telemedicine over the Internet for the International Symposium on Informatics to be held in Moscow on June 25. SBC suggested that the demonstration be

an interactive case consultation using Microsoft NetMeeting. In anticipation, SBC and BCM experimented and practiced using personal computers to conduct interactive audio/video conferences on the Internet. Several days before the event, a hurricane struck Moscow and disrupted telecommunications to the degree that it was unwise to attempt to demonstrate telemedicine on the Internet at the Symposium.

Several days thereafter, because of the success of the rehearsals, Dr. Sukhanov asked if BCM could consult with him and his colleagues about the advisability and feasibility of by-pass surgery for a patient in Moscow. A chronicle of the events follows.

July 1 SBC suggests an Internet-based medical consult for a patient from the Moscow Institute of Transplantology.

July1 BCM suggests a real-time conference using Microsoft NetMeeting to settle details for the medical consultation conference including Internet protocol (IP) addresses for the conference, language of the conference, and

presence of the patient at the conference.

- July 7 BCM and SBC conduct a test of Microsoft NetMeeting conference. Audio delay does not seem to be a problem. The features of the whiteboard will be very helpful. SBC plans to send the patient profile on July 10.
- July 8 SBC sends the clinical case in Microsoft Word as an attachment to e-mail. Also sends an IP address for the retrieval of echocardiograms from server at SBC.
- July 9 BCM retrieves echocardiograms in MPEG format from server at SBC using FTP Explorer. Using the WWW browser Netscape Navigator, BCM transferred electrocardiographs (jpg), angiograms (mpg), and medical history (rtf) from the World Wide Web server at SBC. The connection to server is 29 hops; the round trip time averages over 770 milliseconds and generally over 20% of the packets are lost.
- July 10 BCM cardiologist examines the patient's data on an HP Pavilion with 64 MB RAM with 200 MHz Pentium processor using a 17-inch HP Pavilion monitor with an 800 x 600-pixel desktop set for 16 bit color. JPEG images are viewed with LView Pro. MPEG images are viewed by Microsoft ActiveMovie. Cardiologist's report is dictated and transcribed into Microsoft Word 97. The report is then copied and pasted into an e-mail and sent to SBC. BCM offers to conduct an interactive conference on the Internet on July 14.

July 13 SBC acknowledges receipt of cardiologist's report and confirms appointment for conference on July 14.

July 14 Physicians from SBC and BCM confer in English via the Internet using the audio and video features of Microsoft NetMeeting. Computer at BCM is a Toshiba Tecra (laptop) with a Pentium 233 MHz processor and 160 MB of RAM. An external 17-inch monitor is attached.

In this paper we will:

describe how the data were compiled and viewed at BCM in Houston,

describe the teleconference between SBC and BCM,

discuss the observations of the medical consultants regarding the data and the process, and

discuss future steps.

At BCM, a different computer was used to compile and present the patient's data than was used to conduct the teleconference. Table 1 describes the desktop computer hardware and software used to support this telemedicine episode.

Compilation and Viewing of Patient Data

The history and physical were sent to BCM as an e-mail attachment in rich text format. At BCM, the history and physical were read and printed using Microsoft Word 97.

Diagnostic studies were performed at the Moscow Institute of Transplantology. Briefly a full cardiovascular evaluation was completed which included a cardiac catheterization with left ventriculogram, and EKG, a chest x-ray, and a stress-

echocardiogram. The diagnostic images were digitized and stored in Moscow.

Six angiograms were retrieved using the WWW browser from the SBC web site. These clips were downloaded by BCM using the "Save Image As ..." feature in the browser. The total file size was 2.72 megabytes. The angiograms were viewed using Microsoft ActiveMovie Control.

The electrocardiograms were downloaded from the SBC web site in JPEG format. They were viewed and printed using LView Pro.

The echocardiograms were transferred from a private FTP server at SBC using FTP Explorer. There were nine echocardiograms in MPEG format. The size of the nine files was approximately 19.8 megabytes. The time to transfer the files over the Internet from SBC to BCM was nominal. The echocardiograms were viewed using Microsoft ActiveMovie Control.

The images were high resolution and easily interpretable on an HP Pavilion with 64 Mb RAM with 200 MHz Pentium processor and a 17-inch monitor. There was no loss in the quality of the images upon transmission and several observations from the history conveyed discrepancies between the patient's symptoms and the diagnostic studies which would require further investigation during the real-time conference to explore therapeutic options on the patient.

The patient was a 60-year-old gentleman with a history of coronary heart disease for about five years who had recognized pericardial chest pain with exertion. His prior cardiac history included an inferior wall myocardial infarction in 1996. His symptoms of angina had increased in frequency and intensity. No mention was

made of symptoms of congestive heart failure.

Observations

All diagnostic studies were reviewed. The EKG revealed sinus mechanism with left bundle branch block. The coronary angiogram demonstrated proximal occlusion of the circumflex artery and proximal occlusion of the right coronary artery; there was no evidence of collateral flow to adjacent vessels. The left anterior descending artery was viewed only in the RAO projection, however demonstrated no significant stenosis. The left ventriculogram revealed an ejection fraction of 40% and hypokinesis and akinesis of the basal posterior segment of the left ventricle. A stress echocardiogram was performed which showed akinesis of the septum and septal apical segments. The discrepancies between the coronary arteriogram and the stress echocardiogram were concerning to the consultants in that the angiogram did not demonstrate significant left anterior descending stenosis. However the stress echo suggested local wall motion abnormalities in the distribution of the left anterior descending artery. By angiogram there was no evidence of filling of the distal vessels. Technically, bypass surgery would be difficult in view of complete occlusion of the RCA and the circumflex arteries without distal filling of the vessels. Therefore, it was recommended that a viability study be performed to assess viability in the anterior wall. In addition, it was recommended that several views should be completed to view the LAD in the LAO position by angiogram - this would be highly helpful to shed some light on the differences between the stress echo and the angiogram - as a significant fixed obstruction may be unmasked and may be amenable to angioplasty and/or surgical revascularization.

These observations were discussed extensively in a real-time conference using Microsoft NetMeeting and pivotal issues regarding the patients long term management were agreed upon. Furthermore, critical data imperative to our final recommendation were discovered which may completely change the course of this patient's surgical management.

Future Steps

Telemedicine and consultations between referring physicians has been demonstrated for the first time on the Internet. A complicated series of diagnostic tests were transmitted across the Internet and successfully interpreted to benefit a patient. The capacity to link diagnostic studies and history and physical and transmit them to other facilities will revolutionize medical practices as experts in disciplines in medicine will now be able to interact in real-time during an office visit. The future of these technologies will rest with upgrading the current medical offices to accommodate processing of information from around the world. Furthermore, this cross talk between different disciplines of medicine shall allow creative strategies to address patients' illnesses. This consultation clearly demonstrated that additional information will be crucial to make final recommendations and that in the future, consultations such as this will take place in every physician's office and can also be performed from patients' homes to their respective physicians.

Acknowledgement

This event was partly supported by the Texas Medical Center and the U.S. National Space and Aeronautics Administration.

1. Recent Developments in the Management of Heart Disease. Moderated by M. E. DeBakey and Oleg S. Medvedev, M.D. October 22, 1996. Presentations: Neurologic Protection in Aneurysm Surgery, John C. Baldwin, M.D., Professor and Chairman, Department of Surgery; Organ Preservation Using Subzero Cooling Techniques, George V. Letsou, M.D., Associate Professor, Department of Surgery; Reports from the Clinical Trials of the New Cholesterol Reducing Drugs, Antonio M. Gotto, M.D., Professor and Chairman, Department of Medicine; Predictors of Cardiovascular Myopathy: A Glimpse of the 21st Century from Present Day Molecular Genetics, Robert Roberts, M.D., Professor, Department of Medicine; Coronary Angioplasty and Restenosis: Biological versus Mechanical Approach, William Winters Jr., M.D.

2. International Symposium: New Information and Computer Technologies in Medicine. Moderated by M. E. DeBakey, M.D. January 30, 1997. Presentations: Neonatal Echocardiography, G. Wesley Vick, III, M.D., Ph.D., Assistant Professor, Department of Pediatrics; Children's Immunization Data Registry, Dennis R. Moreau, Ph.D., Assistant Professor, Department of Community Medicine, Director, Center for Information Infrastructure and Computing Sciences; and Medical Informatics and Clinical Decision Making, J. Robert Beck, M.D., Professor of Pathology, Vice President for Information Technology

3. Global Clinic: Ventricular Assistance. M.E. DeBakey. March 18, 1997. Presented to audiences at the American Medical Association Executive Council Meeting in Philadelphia, PA and at the Moscow State University in Moscow Russia.

Table 1. Computer Configurations

	BCM Physician's Computer	BCM Conference Computer	SBC
Make	Hewlett Packard	Toshiba	Lampont System
Model	HP Pavilion 7360	TECRA 750CDM (Laptop)	A-Open 2 -300MMX/6
Processor & Speed	200 MHz Pentium with MMX technology	233 Pentium with MMX technology	300 Pentium II with MMX technology
Memory	64.0 MB RAM	160.0 MB RAM	64.0 MB RAM
Disc Drive Capacity	3.8 GB	4.77 GB	6.8 GB
Monitor Make	Hewlett Packard	Toshiba	Acer
Monitor Model	HP Pavilion 17" Multimedia Display (Model D3859A)	Toshiba 13.3" diagonal TFT active matrix color display	AcerView 76c, 17" CRT Size
Video Card	S3 VIRGE PCI		ATI Xpert@Play AGP
Screen Size (diagonal)	15.75 inches	External Monitor: Toshiba 17" autoscans monitor	15.75 inches max. Viewable area
Dot pitch	0.28 mm		0.27 mm
Resolution	800x600	800x600	1024x768
Color	16 bit	256 for dual display control	24 bit
Video Capture Card	Winnov Videum AV Board	Toshiba DVD Decoder Board Ver2.0	FlyVideo-EZ2 PCI
Camera	Winnov Color Video Camera XC75B/495	Toshiba NoteBook Built-in Conferencing System	FlyCam
Audio Card	Winnov Videum AV Board	Yamaha OPL3-SA3 Sound System	AW35 Pro
Microphone	Telex	Koss	standard
Sound Card	Winnov Videum AV Board		
Speaker	ALTEC Lansing Multimedia	QIC 8860 Multimedia Amplified Speakers	J-340AV Multimedia Amplified Speakers
Operating System	Microsoft Windows 95 v. 4.00.950B	Microsoft Windows 95 v.4.00.950B	MS Windows 95 v.4.00.950B
E-mail Application	Eudora Pro from Qualcomm v. 3.0.1		
Image Viewer Application	LView Pro CD-ROM Edition	Lview Pro Image Processor, v.2.0	MS Photo Editor 3.0
WWW Browser	Netscape® Navigator 4.03	Netscape Communicator 4.04	MS Internet Explorer 3.0(4.70.1158)
MPEG Viewer Application	Microsoft ActiveMovie Control v. 2.0	Microsoft ActiveMovie Control v.2.0	Windows Media Player 5.01.52.0701
FTP Application	FTP Explorer v. 1.00 by FTPx Corporation		
Digitizing Application - moving images			MiroVideoDP30
Scanner for EKG's			Mustek Paragon 1200 SP
Internet	Ethernet 10 mbps TCP/IP	Ethernet 10 mbps TCP/IP	Ethernet 256 kbps TCP/IP
NIC	3Com Etherlink III (3C509b-TP)	Noteworthy Ethernet LAN PC Card	Intel EtherExpress PRO/100